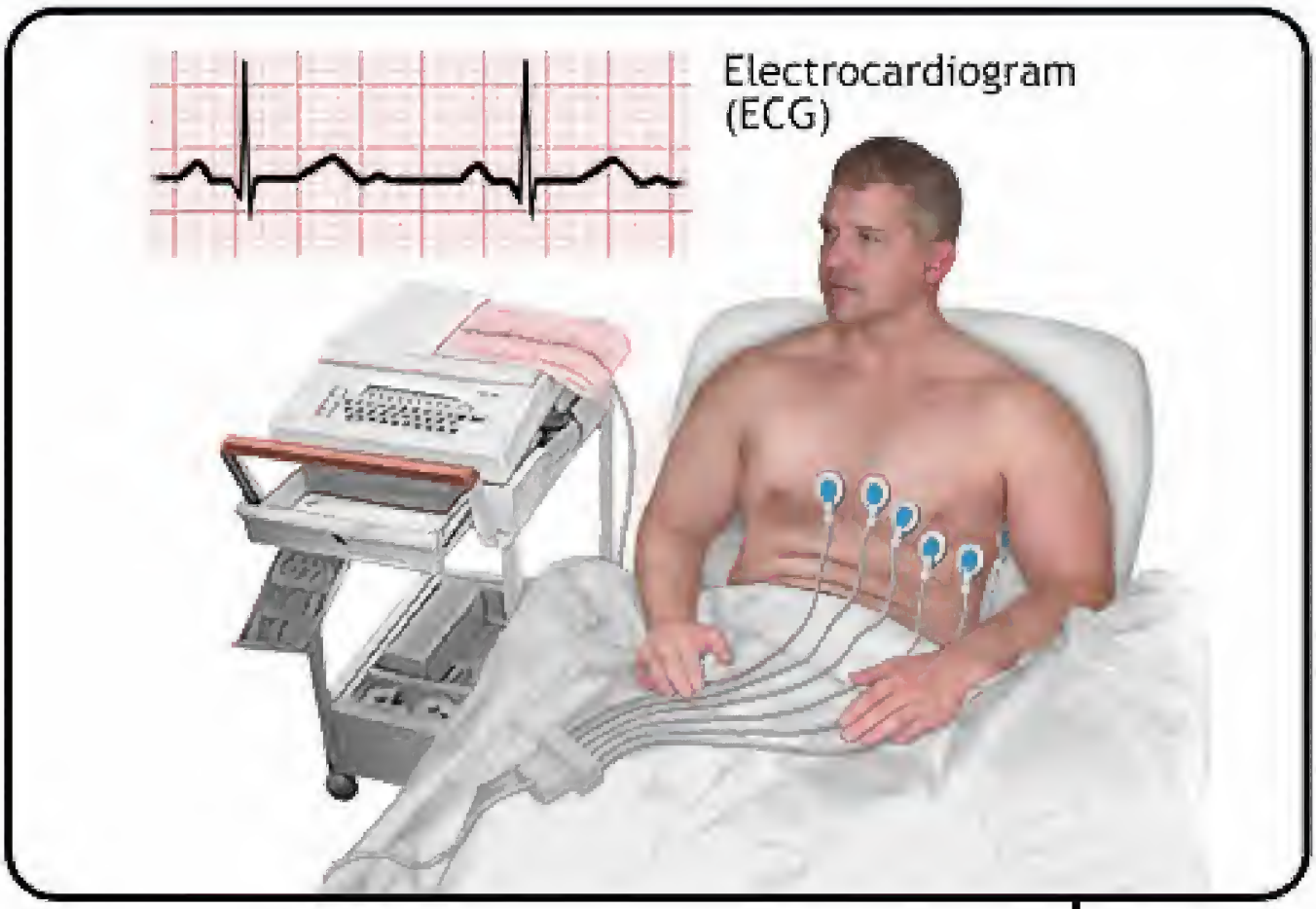
# Summary of ECG




NOTES OF MEDADTEAM

- Special thanks to Dr Ashraf Zaki



MEDADTEAM

2010

1.5 L.E.

# Summary of ECG

1. Take a look at the leads & determine location of each wall:

| | | | |
|---|---|---|---|
| I High lateral | aVR | V1 Septal | V4 Strict anterior |
| II Inferior | aVL High lateral | V2 Septal | V5 Low lateral |
| III Inferior | aVF Inferior | V3 Strict anterior | V6 Low lateral |
| II | | | |

2. Make spot diagnosis

3. Use the scheme to:
   - Confirm diagnosis
   - Correct diagnosis
   - Complete diagnosis

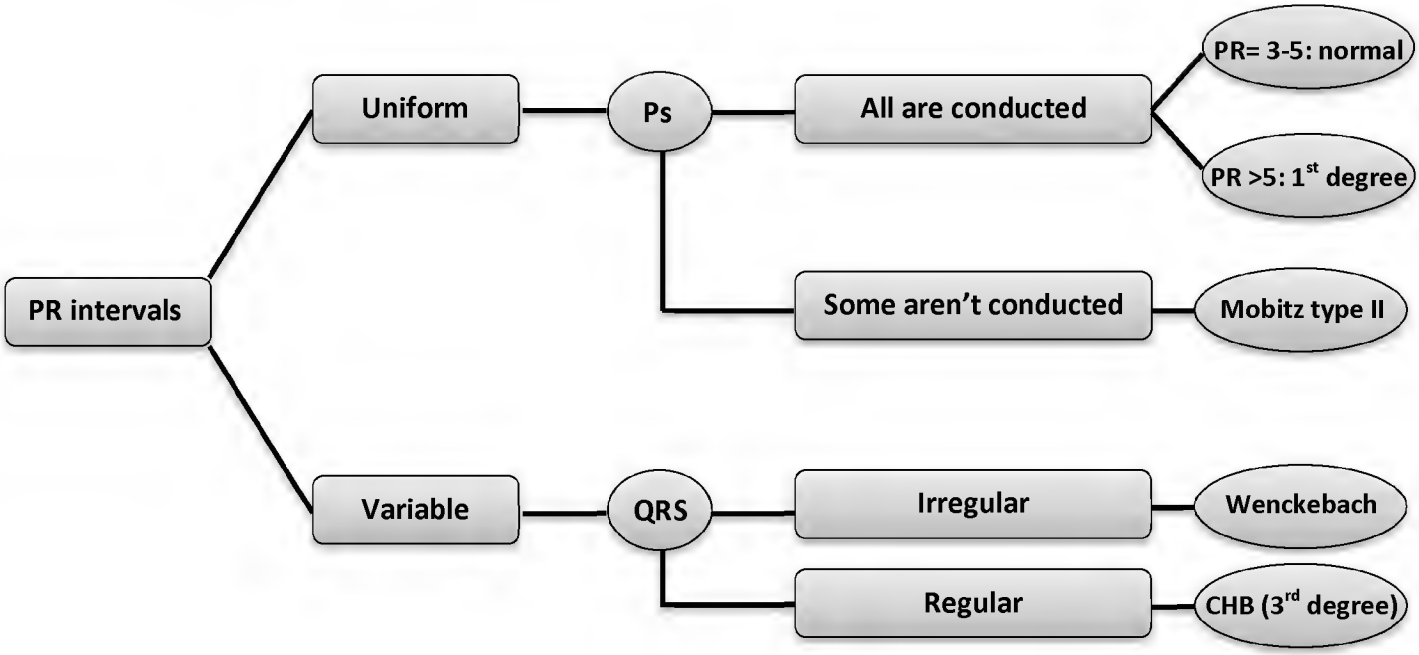
## Scheme for ECG

| | Abnormality | Leads to look at | |
|---|---|---|---|
| | | Limb leads | Chest leads |
| Step I | **AV block** | Strip or II | |
| | **Arrhythmia** | | |
| Step II | **Atrial enlargement** | II | V1 |
| | **Bundle Branch Block** | | V1, V2, V5, V6 |
| | **Ventricular enlargement** | | |
| Step III | **Axis** | I/III or aVF | |
| | **Hemiblock** | Limb leads | |
| Step IV | **Myocardial infarction** | I, L → high lateral wall<br>II, III, F → inferior wall<br>V1, V2 → septal wall<br>V3, V4 → strict anterior wall<br>V5, V6 → low lateral wall | |
| | **Myocardial ischemia** | | |
| Step V | **Low voltage** | I, II, III | |
| | **Digitalis** | In all limb leads | |
| | **Hyperkalemia** | In all limb leads | |
| | **Pre-excitation syndrome** | In all limb leads | |

**Normally:**

- **P wave**: height ≤2.5 small squares – width < 3 small squares.
- **PR interval (P wave + PR segment)**: width= 3-5 small squares.
- **QRS**: width < 2.5 small squares – height in LI + LII + LIII > 15 small squares.

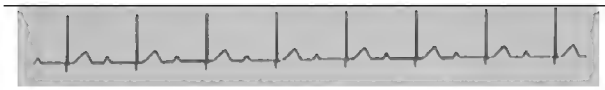
# Step 1:
# I.1 Atrioventricular Block




In second degree only (wenckebach & Mobitz type II):

1- Detect degree of block (P: QRS ratio -> 6:5 or 5:4 or 4:3 etc.....).
2- If block is 2:1, look at the width of the QRS:
   - If wide > 2.5 = Mobitz type II.
   - If narrow = wenckebach.
3- If shortest PR > 5 in wenckebach or PR > 5 in Mobitz type II = 1st degree Av block is associated.

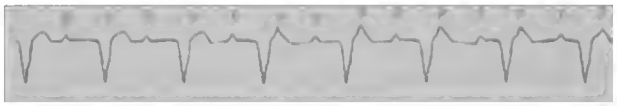
**First Degree AV Block**



**Mobitz Type II Second Degree AV Block**

**Mobitz Type I (Wenckebach) Seconed Degree AV Block**


**3rd Degree (Complete) Heart Block**



# I.2 Arrhythmia:

## 1. Regularity:

- **Regular:**
  **Definition:** uniform R-R intervals +/- 1mm
  **How to decide:**
  - By paper or divider
  - If NO strip: compare R-R intervals in different leads
  - If NO R-R in leads: do NOT comment on regularity
- **Irregular:**
  **Definition:** variable R-R
  **Possibilities:**
  - Regular irregularity
  - Irregular irregularity
- **Regular with occasional irregularity:**
  **Definition:** ALL R-R are regular except one i.e. premature beat

## 2. Rate: (heart rate)

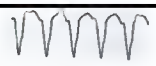
- **If regular R-R interval:**
  Count number of squares (big or small) in R-R interval
  $\text{Rate} = \frac{300}{\text{R–R in big squares}}$ or $\frac{1500}{\text{R–R in small squares}}$
- **If irregular R-R interval:**
  - If strip is
    10 big squares, so rate = number of QRS X 30
    20 big squares, so rate = number of QRS X 15
    30 big squares, so rate = number of QRS X 10
  - Whether strip is present or not, choose THE MOST MIDDLE R-R INTERVAL(استوسطلك واحدة),
    So rate = $\frac{300}{\text{MOST MIDDLE R–R in big squares}}$

If NO strip & NO R-R in leads (one complex in each lead), do NOT comment

## 3. Pacemaker:

**Scheme for pacemaker**

| Pacemaker | How to know | | If the pacemaker is ..., so think about ..... | |
|---|---|---|---|---|
| **Sinus pacemaker** | P wave:<br>- Upright in II &<br>- Inverted in aVR |  | **Normal sinus rhythm**<br>**Sinus tachycardia**<br>**Sinus bradycardia**<br>**Sinus arrhythmia**<br>**Sinus pause** | Differentiated by **regularity & rate** |
| **Atrial pacemaker** | NO sinus P wave<br>P wave according to rhythm |  | **Atrial ectopic focus**<br>**Atrial fibrillation**<br>**Atrial flutter**<br>**Multifocal atrial tachycardia**<br>**Wandering atrial tachycardia** | Differentiated by **features of each pacemaker** |

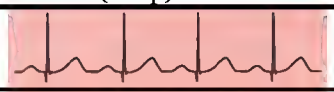
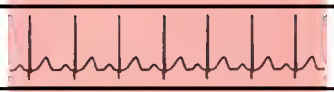
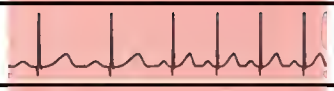
| | | | | |
|---|---|---|---|---|
| **Junctional pacemaker** | P wave:<br>- Absent OR<br>- Retrograde:<br>Inverted in II,<br>Upright in aVR<br>Just before or just after QRS |  | **Supraventricular tachycardia**<br>**Escape Junctional rhythm**<br>**Accelerated Junctional rhythm** | Differentiated by **rate** (as ALL are regular) |
| **Ventricular pacemaker** | - Wide QRS<br>Except suprahesal<br>- T direction is opposite to QRS<br>- +/- signs of AV dissociation |  | **Ventricular tachycardia**<br>**Escape idioventricular rhythm**<br>**Accelerated idioventricular rhythm** | Differentiated by **rate** (as ALL are regular except multifocal VT) |
| | | | **Ventricular fibrillation**<br>**Ventricular flutter** | **Spot diagnosis** |
| **Artificial pacemaker** | Spikes before QRS<br>+/-P wave |  | **Ventricular pacemaker**<br>**Dual pacemaker** | Differentiated by **spikes** |

## For determining type of arrhythmia

1. **Determine the pacemaker**
2. **Decide which type of arrhythmia according to the rate and regularity**

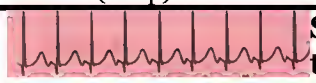
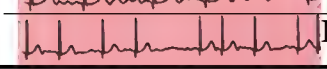
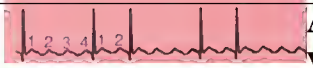
# I. Sinus pacemaker:

**Scheme for Sinus Pacemaker**

| 1.pacemaker | 2. decide arrhythmia | | | |
|---|---|---|---|---|
| | Regularity | Rate | Lead II (Strip) | Rhythm (Diagnosis) |
| **Sinus rhythm**<br>P wave:<br>• Upright in II<br>• Inverted in aVR | Regular | **60-100** |  | **Normal sinus rhythm** |
| | | **100-180** |  | **Sinus tachycardia** |
| | | **40-60** |  | **Sinus bradycardia** |
| | **Irregular** | Any |  | **Sinus arrhythmia** |
| | **Regular with OI (Dropped beat)** | |  | **Sinus pause (Sick Sinus Syndrome)** |

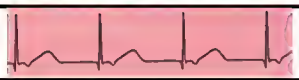
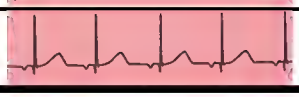
# II. Atrial pacemaker:

## Scheme for Atrial Pacemaker

| 1.pacemaker | 2.deciding arrhythmia | | | | |
|---|---|---|---|---|---|
| | Pacemaker | Regularity | Rate | Lead II (Strip) | Rhythm (Diagnosis) |
| **Atrial pacemaker** NO sinus P wave | Small P waves | Regular | >150 |  | **Supraventricular tachycardia** |
| | **Fibrillatory waves Absent P** | Irregular | Any |  | **Coarse** — **Atrial fibrillation** |
| | | | |  | **Fine** |
| | **Flutter waves (Saw teeth)** | **Regular** | Any |  | **Atrial flutter 4:1** |
| | | **Irregular** | |  | **Atrial flutter with variable block** |
| | ≥ 3 different Ps | Irregular | **Tachycardia** |  | **Multifocal atrial tachycardia (MAT)** |
| | | | **Bradycardia** |  | **Wandering atrial pacemaker** |

# III. Junctional pacemaker:

## Scheme for Junctional Pacemaker

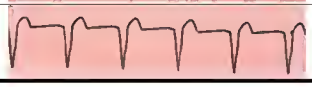
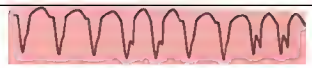
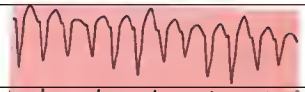
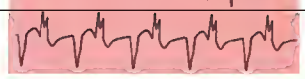
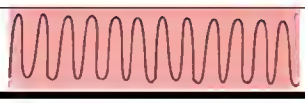
| 1.pacemaker | 2.decide arrhythmia | | | |
|---|---|---|---|---|
| | Regularity | Rate | Lead II (Strip) | Rhythm (Diagnosis) |
| **Junctional Pacemaker** P absent or retrograde | Regular | **>150 (>100)** |  | **Supraventricular tachycardia (PAVNRT)** |
| | | **40-60** |  | **Escape Junctional rhythm** |
| | | **60-100** |  | **Accelerated Junctional rhythm** |

**ALL junctional rhythms are REGULAR, unlike fine AF which is IRREGULAR**

| **Junctional rhythm (supraventricular tachycardia)** | **Atrial Fibrillation** |
|---|---|
| **Absent P wave** | |
| Regular | Irregular |

# IV. Ventricular pacemaker:

## Scheme for ventricular Pacemaker

| 1.pacemaker | 2.decide arrhythmia | | | | |
|---|---|---|---|---|---|
| | Pacemaker | Regularity | Rate | Lead II (Strip) | Rhythm (Diagnosis) |
| **Ventricular pacemaker**<br>Wide QRS<br>T inversion<br>AV dissociation | | | **>150** |  | **Ventricular tachycardia** |
| | | | **<40** |  | **Escape idioventricular rhythm** |
| | | | **60-100** |  | **Accelerated idioventricular rhythm** |
| | | | | Don't exceed 30 seconds<br>3 or more beats | **NON sustained ventricular tachycardia** |
| | | Irregular | Tachy |  | **Multifocal ventricular tachycardia** |
| | | | |  | **Torsades de pointes** |
| | | | |  | **Bidirectional Ventricular tachycardia** |
| **NO QRS** | **Vent. fibrillatory waves** | Irregular | Any |  | **Ventricular fibrillation** |
| | **Ventricular flutter waves** | Regular | 300-400 |  | **Ventricular flutter** |

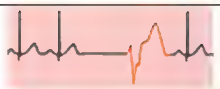
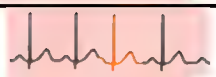
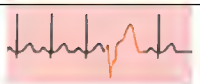
# V. Ectopic beats

## Scheme for Ectopic Beats

**1. Decide whether ectopic beat is escape or premature**

| If | ,so |
|---|---|
| Sinus rhythm<br>→pause<br>→ectopic beat<br>→sinus rhythm | **Escape beat** |
| Sinus rhythm<br>→ectopic beat<br>→pause<br>→sinus rhythm | **Premature beat** |

**2.Decide whether ectopic beat (escape or premature) is atrial, Junctional or ventricular**

| If | | ,So diagnosis |
|---|---|---|
| Small (atrial) P wave |  | **Escape atrial beat** |
| Retrograde P wave |  | **Escape Junctional beat** |
| Wide QRS<br>T wave<br>opposite QRS |  | **Escape ventricular beat** |
| Small (atrial) P wave |  | **Premature atrial beat** |
| Retrograde P wave |  | **Premature Junctional beat** |
| Wide QRS<br>T wave<br>opposite QRS |  | **Premature ventricular beat** |

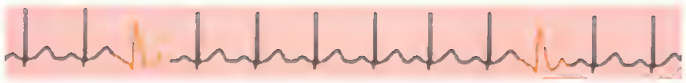
| Premature | Pause |
|---|---|
| Less than | 2 Normal cycles |

| Premature | Pause |
|---|---|
| equal | 2 Normal cycles |

## Variable forms of premature beats:

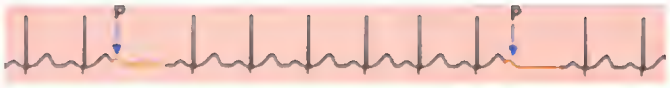
### 1) Premature atrial beat with aberrant conduction (Ashmann phenomenon):

Premature atrial beat occurs so early that it reach the ventricles during relative refractory period.
So upstroke of ventricular depolarization is slow and intraventricular conduction of the impulse is slow with subsequent wide QRS.



### 2) Premature atrial beat with non-conducted P:

Premature atrial beat occurs more early than the mentioned above, so it reaches the ventricels during absolute refractory period → no QRS




### 3) Monofocal premature beat:

**Scheme for Monofocal Premature Beat**

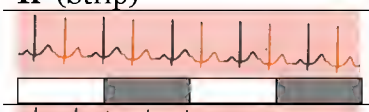
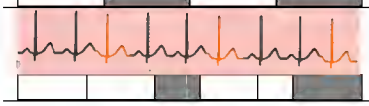
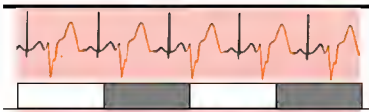
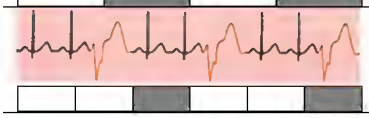
**Monofocal premature beat**

**Premature beat occurs every constant number of sinus beats**

**1.Decide whether premature beats are atrial or ventricular**

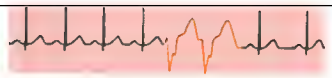
| If | ,So |
|---|---|
| Small P wave | **Atrial premature beats** |
| Wide QRS T wave opposite QRS | **Ventricular premature beat** |
| Retrograde P wave | **Junctional premature beats** |

**2.Decide whether premature beats are bigeminy, trigeminy or quadrigeminy**

| If (Strip) | ,So |
|---|---|
|  | **Atrial bigeminy** |
|  | **Atrial trigeminy** |
|  | **Atrial quadrigeminy** |
|  | **Ventricular bigeminy** |
|  | **Ventricular trigeminy** |
|  | **Ventricular quadrigeminy** |
|  | **Junctional bigeminy** |
|  | **Junctional trigeminy** |
|  | **Junctional quadrigeminy** |

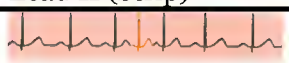
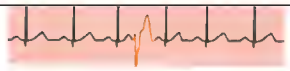
## 4) Couplet:

**Scheme for Couplet**

| How to know | | If | Lead II (Strip) | ,So diagnosis |
|---|---|---|---|---|
| Sinus rhythm →premature beat →premature beat →sinus rhythm | Couplet | Small P wave |  | **Atrial couplet** |
| | | Retrograde P wave | | **Junctional couplet** |
| | | Wide QRS T wave opposite QRS |  | **Ventricular couplet** |

## 5) Interpolated premature beat:

Scheme for Interpolated Premature Beat

| How to know | | If | Lead II (Strip) | ,So |
|---|---|---|---|---|
| Sinus rhythm →premature beat →sinus beat (NO pause) Premature cycle + return cycle = **ONE** normal sinus cycle | Interpolated premature beat | Small P wave |  | **Interpolated PAB** |
| | | Retrograde P wave | | **Interpolated PJB** |
| | | Wide QRS T wave opposite QRS |  | **Interpolated PVB** |

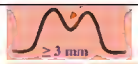
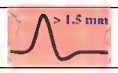
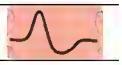
# Step II

## II.1. Atrial enlargement:

**Look at**

| | | | |
|---|---|---|---|
| | | V1 | |
| II | | | |
| | | | |
| | | | |

**Scheme for atrial enlargement**

| | II | | V1 | |
|---|---|---|---|---|
| **Normal** | Positive, W<3mm, H≤ 2.5mm | | Biphasic | |
| **Left** | Broad, P mitral | W>=3mm +/- notched  | -ve > 1x1 |  |
| **Right** | Tall and peaked, P pulmonale | H>2.5  | +ve > 1.5 in H |  |
| **Biatrial** | P mitral & P pulmonale |  | +ve P is tall >1.5 & -ve P is board >1 |  |

**For diagnosis of atrial enlargement, a change in ONE lead is ENOUGH**

# II.2. Bundle Branch Block:

**Look at**

| | | | |
|---|---|---|---|
| | | V1 | |
| | | V2 | V5 |
| | | | V6 |
| | | | |

**Spot diagnosis: WIDE QRS at V1, V2, V5, V6**

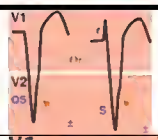
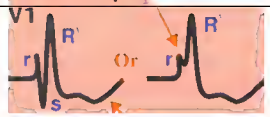
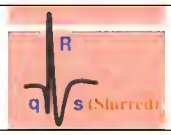
**i. Is QRS complex (Normal < 2.5mm) wide?**

**If >3mm → complete BBB**

**If 2.5-3mm → incomplete BBB**

**ii. In both cases, determine whether right or left:**

## Scheme for Bundle Branch Block

| | V1, V2 | | V5, V6 & I | |
|---|---|---|---|---|
| **LBBB** | QS or rS |  + | Monophasic R with secondary inversion of T wave |  |
| **RBBB** | rSR' or monophasic R with secondary inversion of T wave |  + | qRs (with slurred s) |  |
| **IVCD** | LBBB | + | RBBB | |
| | RBBB | + | LBBB | |

➢ **If RBBB is diagnosed, NEVER diagnose:**

- **Ventricular enlargement**
- **Myocardial ischemia**

➢ **If LBBB is diagnosed, NEVER diagnose : above conditions+**

- **Myocardial infarction** (diagnosed if new onset LBBB with typical ischemic chest pain or elevated cardiac enzymes )
- **Hemiblock.**

➢ **Pacemaker: in LBBB ONLY (or IVCD)**

**If LBBB is associated with spikes, this indicates pacemaker:**

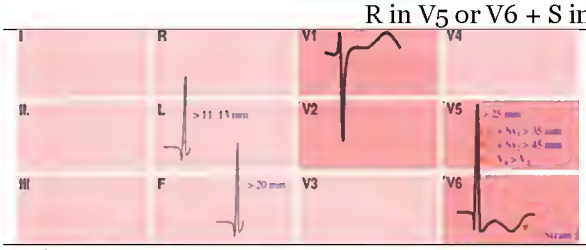
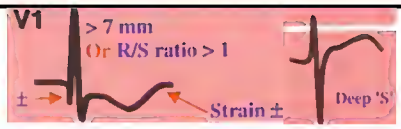
- **If one spike (before QRS) → ventricular pacemaker**
- **If TWO spikes ( one before P, and other before QRS) → Dual pacemaker**
- **If spike is NOT followed by QRS → malfunctioning pacemaker**

## II.3. Ventricular enlargement:

**Look at**

| | | | |
|---|---|---|---|
| | | V1 | |
| | | V2 | V5 |
| | | | V6 |
| | | | |

### Scheme for Ventricular Enlargement

| | V1, V2 | V5, V6 |
|---|---|---|
| **LVE** | 6 features (ANY one is diagnostic, but ALL must be excluded negative to exclude LVE) | |
| | | R in V5 or V6 > **25 mm** (5 big squares) |
| | R in V5 or V6 + S in V1 > **35 mm** (7 big squares)<br>R in V5 or V6 + S in V2 > **45 mm** (9 big squares) | |
| |  | R in V6 > R in V5 |
| | R in aVL > **13 mm**<br>R in aVF > **20 mm** | +/- ST depression( strain sign) = hypertrophy > dilatation |
| **RVE** | Tall R in V1 > 7 mm or R in V1 ≥ S in V1<br>Deep S in V6<br>+/- ST depression( strain sign) = hypertrophy > dilatation |  |
| **BVE** | Signs of LVE + tall R in V1 or Signs of LVE + Rt. Axis deviation. | |

# Step III

## III.1. Axis:

**Look at:**

| | | | |
|---|---|---|---|
| I | | | |
| | | | |
| III | aVF | | |
| | | | |

### Scheme for Axis

| | Normal axis deviation | Left axis deviation | Right axis deviation | Extreme axis deviation |
|---|---|---|---|---|
| I |  |  |  |  |
| III or aVF |  |  |  |  |

**IF THE AXIS IS DEVIATED, SEARCH FOR HEMIBLOCK**

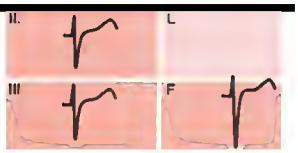
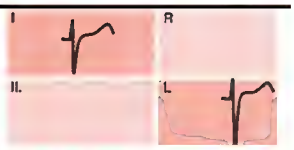
## III.2. Hemiblock:

**Look at: inferior and high lateral leads**

| | | | |
|---|---|---|---|
| I | | | |
| II | aVL | | |
| III | aVF | | |
| | | | |

**Search for hemiblock if axis is deviated**

### Scheme for Hemiblock

| | | | | |
|---|---|---|---|---|
| **LAHB**<br>Left anterior HB | Left axis deviation |  | Deep S in inferior leads (II, III, aVF) in aVF especially (as normal in III)<br>(NO need to exclude other causes of left axis deviation) |  |
| **LPHB**<br>Left posterior HB | Right axis deviation |  | Deep S in high lateral leads (I, aVL)<br>(provided that it is NOT explained by RVE) |  |

**NB** | If hemiblock + RBBB → **Bifascicular block hemiblock**
If hemiblock + RBBB + 1st HB → **Trifascicular block hemiblock**

# Step IV

## IV.1.2. Myocardial infarction and ischemia:

**Search for ALL changes in EACH lead**

**Changes:**

**i. Is there Pathological Q (or poor progression of R)?**
**ii. Is there ST elevation (or ST depression)?**
**iii. Is there T inversion (or hyperacute, biphasic or flat T wave)?**

**CHANGES must be in 2 SUCCESSIVE LEADS of the SAME WALL**

- **Pathological Q:**
  - Wide (≥ 1mm) & deep (≥= 2mm or ≥ ¼ the following R)
  - In 2 successive lead of the same wall
- **Poor progression of R: in anterolateral infarction**
  - R is NOT >S in V4
- **ST elevation:**
  - First mm after J point is elevated than isoelectric line
  - Isoelectric lines (baseline) are P-R segment or T-P segment
  - Considered elevated if:
    - ≥ 1mm in limb leads
    - ≥ 2mm in chest leads

- Determine straightened or coved according to T wave & J point elevation
- **These changes MUST be IN 2 SUCCESSIVE LEADS of the SAME WALL**

## If:

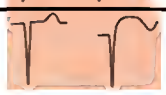
- ST elevation (+/- ST depression in other walls) → **ST elevation Myocardial Infarction (+/- reciprocal ST depression)**
- ST depression ONLY → **Myocardial ischemia**

## If ST Elevation Myocardial Infarction, determine age & site:

### 1. Age:

**Scheme for age of STEMI**

Spot diagnosis

| Age of STEMI | How to know | | | |
|---|---|---|---|---|
| | ST segment | Q wave | T wave | |
| **Hyperacute** | ST elevation | NO pathological Q | +/- Hyperacute T wave |  |
| **Acute** | ST elevation | Pathological Q Or poor R progression | +/- Hyperacute T wave |  |
| | | | Biphasic (intermediate phase) |  |
| **Evolving** | ST elevation | Pathological Q Or poor R progression | Inverted T |  |
| **Old** | NO ST elevation | Pathological Q Or poor R progression | Normal T |  |

### 2. Site:

| | | | |
|---|---|---|---|
| I High lateral | aVR | V1 Septal | V4 Strict anterior |
| II Inferior | aVL High lateral | V2 Septal | V5 Low lateral |
| III Inferior | aVF Inferior | V3 Strict anterior | V6 Low lateral |

Anteroseptal = V1-V3 +\- V4

Anterolateral =V3-V6+I&aVL

Extensive anterior= V3-V6+I&aVL

Posterior wall MI:

Tall R in V1, V2, V3 – ST depression – upright T

- Associated with inferior myocardial infarction (to differentiate it form RVE)

| RVE | Posterior MI |
|---|---|
| Tall R in V1, V2, V3 | |
| | **Associated with Inferior MI** |

**ST depression in some leads:**

- If associated with ST elevation in other leads → **RECIPROCAL ST DEPRESSION associated with MI**

-If alone → **MYOCARDIAL ISCHEMIA:**

**ST** depression: start after J point, is ≥ 1mm in limb leads or ≥2mm in chest leads & last for >2mm.

**T wave:** flat or symmetrically inverted or symmetrically upright.

# Step V

## V.1. Low voltage:

**Look at**

| | | | |
|---|---|---|---|
| I | | | |
| II | | | |
| III | | | |
| | | | |

**How to know**

- QRS in I + II + III < 15mm

NB | **Electrical alternans in pericardial effusion:**

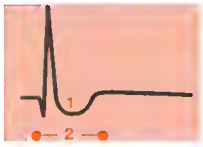
- LOW voltage +

## V.2. Digitalis effect: in ALL LEADs

**Digitalis effect:**

**NB | Normal QT = ½ RR**

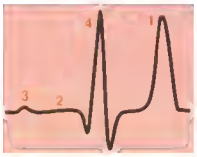
- Short QT i.e. QT < ½ RR
- Sagging ST depression:
  - J point is isoelectric (unlike ischemia)
  - ST depression + T inversion
  - Fused ST & T



## V.3. Hyperkalemia: in ALL LEADs

**How to know:**

**Hyperacute T wave alone** (tall, narrow & peaked)



## V.4. Preexcitation syndrome: in ALL LEADs

**Scheme for prexcitation syndromes**

| WPW-Wolf Parkinson White | LGL-Lawn Ganong Levine |
|---|---|
| • Short PR interval<br>• Delta wave<br>• Wide QRS | • Short PR interval |